(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification⁷: H04B 1/10, 1/30

(21) International Application Number:
PCT/IB2004/050819

(22) International Filing Date: 1 June 2004 (01.06.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/475,755   4 June 2003 (04.06.2003)   US

(71) Applicant (for all designated States except US): KONIN-KLIJKE PHILIPS ELECTRONICS, N.V. [NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven (NL).

(72) Inventor; and

(75) Inventor/Applicant (for US only): PERKINS, Richard [US/US]; P.O. Box 3001, Briarcliff Manor, NY 10510-8001 (US).

(74) Common Representative: KONINKLIJKE PHILIPS ELECTRONICS, N.V.; c/o Aaron Waxler P.O. Box 3001, Briarcliff Manor, NY 10510-8001 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:
— as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for the following designations AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)

[Continued on next page]

(54) Title: ADAPTIVE INTERMODULATION DISTORTION FILTER FOR ZERO-IF RECEIVERS
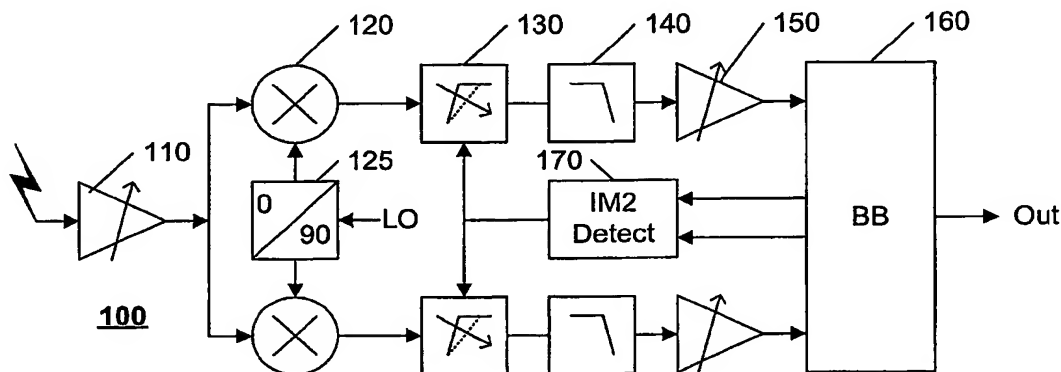
(57) Abstract: A zero-IF receiver includes an adaptive filter that is enabled when intermodulation distortion is detected. The adaptive filter is configured as a notch filter that is centered at the location of the second-order intermodulation distortion, which, in a zero-IF receiver, is at zero Hertz. In a preferred embodiment, the frequency response of the high pass filter that is typically used in a conventional zero-IF receiver is adjusted when intermodulation distortion is detected. Preferably, the detection of the intermodulation distortion is based on one or more of the digital baseband signals, for ease of implementation, but analog processing may also be employed.

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii)) for all designations*

Published:

— *with international search report*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

10/ 520852

ADAPTIVE INTERMODULATION DISTORTION FILTER
FOR ZERO-IF RECEIVERS

This invention relates to the field of communications, and in particular to zero-IF

5 receivers.

Direct down-conversion-to-DC-baseband, or zero-IF (intermediate frequency), receivers are commonly used in portable devices because such receivers can typically be embodied as a single integrated circuit with minimal external components.

Zero-IF receivers, however, have limited inherent ability to reject unwanted second

10 order intermodulation distortion at their output, which typically occurs when an AM (amplitude modulated) interference source is present. Such AM sources include mobile telephone handsets that use TDMA and pulsed GSM signals. The intermodulation distortion caused by these sources cause degraded receiver performance and, in the case of a receiver in a mobile telephone, dropped calls.

15 A variety of techniques are commonly employed to improve a receiver's ability to reject unwanted second order intermodulation distortion, such as component matching and calibration to improve circuit balance, and balancing the duty-cycle of the local oscillator. The success of these techniques, however, has been limited.

It is an object of this invention to provide a method and system to improve a zero-

20 IF receiver's ability to reject second order intermodulation distortion. It is a further object of this invention to provide a method and system for improving a receiver's ability to reject second order intermodulation distortion dynamically. It is a further object of this invention to provide a method and system for improving a receiver's ability to reject second order intermodulation distortion with minimal changes to the structure of a conventional

25 receiver.

These objects, and others, are achieved by providing a zero-IF receiver with an adaptive filter that is enabled when intermodulation distortion is detected. The adaptive filter is configured as a notch filter that is centered at the location of the second-order intermodulation distortion, which, in a zero-IF receiver, is at zero Hertz. In a preferred

30 embodiment, the frequency response of the high pass filter that is typically used in a conventional zero-IF receiver is adjusted when intermodulation distortion is detected.

Preferably, the detection of the intermodulation distortion is based on one or more of the digital baseband signals, for ease of implementation, but analog processing may also be employed.

FIG. 1 illustrates an example block diagram of a zero-IF receiver with adaptive

5   intermodulation distortion filtering in accordance with this invention.

FIG. 2 illustrates an example flow diagram of a method of adaptive intermodulation distortion filtering in accordance with this invention.

FIG. 3 illustrates a second example block diagram of a zero-IF receiver with adaptive intermodulation distortion filtering in accordance with this invention.

10   FIG. 4 illustrates a third example block diagram of a zero-IF receiver with adaptive intermodulation distortion filtering in accordance with this invention.

FIG. 5 illustrates a fourth example block diagram of a zero-IF receiver with adaptive intermodulation distortion filtering in accordance with this invention.

Throughout the drawings, the same reference numeral refers to the same element, or an

15   element that performs substantially the same function.

FIG. 1 illustrates an example block diagram of a zero-IF receiver 100 with adaptive intermodulation distortion filtering in accordance with this invention. The receiver 100 includes a tunable front end 110 whose output is demodulated by a quadrature demodulator to provide quadrature output signals that are processed by a baseband processor 160,

20   typically in digital form. For ease of illustration, only one branch of the quadrature demodulator is described herein, the other branch being functionally equivalent, but operating at an orthogonal phase provided by the quadrature phase generator 125. The output of the front end 110 is demodulated by a mixer 120, and filtered by a filter 130, 140. A tunable amplifier 150 provides a baseband analog signal, which is processed by the

25   aforementioned baseband processor 160 to provide the receiver output.

Second order intermodulation distortion in a receiver appears at the IF-frequency; in the case of a zero-IF receiver, the second order intermodulation distortion appears at zero Hertz (DC). In accordance with this invention, the receiver 100 also includes an intermodulation distortion detector 170 that is configured to dynamically control the filter

30   130 to reduce the effects of second-order intermodulation distortion. The detector 170 is configured to assert a detection signal when intermodulation distortion is detected. In a

straightforward embodiment, when this detection signal is asserted, the filter 130 is enabled; otherwise, it is bypassed. In a more typical embodiment, the function of the filter 130 is incorporated into one or more existing filters in a typical receiver, as discussed further below.

5   A zero-IF receiver commonly includes a high-pass filter at zero Hertz that is used as a very narrow notch filter for removing the DC component from received signals. This DC notch filter is often configured as part of a DC tracking loop that optimizes the receiver sensitivity and minimizes fading for optimal data rate performance. Often, as part of a tracking loop, the DC notch filter is configured to provide adjustable frequency response,

10   depending upon whether the loop is in a search-mode or lock-mode.

        In a preferred embodiment of this invention, the filter 130 comprises a filter having an adjustable frequency response, so that it can be also used as the aforementioned conventional DC notch filter for optimizing the receiver sensitivity. Under normal conditions, in the absence of detected intermodulation distortion, the filter 130 is

15   configured as a conventional narrow DC notch filter. When intermodulation distortion is detected, the filter 130 is configured as a wider DC notch filter, to filter-out second order intermodulation distortion by attenuating signal components of the baseband signal in the frequency band of the intermodulation distortion. Typically, the narrow-mode of the filter 130 has a notch width of about +/- 1 kHz, while the wide-mode of the filter 130 has a

20   notch-width of about +/- 60 kHz. Although the intermodulation distortion may be narrower or wider than +/- 60 kHz, depending upon the source of the distortion, this notch-width has been found to substantially reduce the effects of commonly occurring second-order intermodulation distortion while still retaining adequate receiver performance.

        If the filter 130 is also part of the aforementioned DC tracking loop, the filter 130 is

25   also configurable to a third frequency response, corresponding to the aforementioned DC tracking search mode. The search-mode notch-width will be dependent upon the desired response time and sensitivity of the DC tracking loop.

        Preferably, the intermodulation distortion detector 170 uses digital signals from the baseband processor 160 to determine whether intermodulation distortion is present, as

30   discussed further below.

FIG. 2 illustrates an example flow diagram of a method of adaptive intermodulation distortion filtering in accordance with this invention. At 210, the receiver is placed in the "normal-mode", wherein the intermodulation filter (130 in FIG. 1) is bypassed or, if the filter is also used as the conventional DC notch filter as discussed above, it is set to the

5   aforementioned narrow-mode. To assure proper 'normal' performance, the receiver is preferably kept in the normal-mode for some minimum time, Nmin, via the timing test at 220. If, at 220, the minimum normal-mode time has elapsed, measures of the intermodulation distortion are obtained, at 230. The process remains in loop 230-240 until the measures indicate that the distortion is at or above some minimum level IMmin.

10 If, at 240, the measures indicate intermodulation distortion above the minimum level IMmin, the receiver is placed in the "wide-mode", wherein a DC notch filter with a notch-width of about +/- 60 kHz is engaged, at 250. At 260, the measures of intermodulation distortion are obtained again, and compared with the measures taken in the normal-mode, at 270. If the measures indicate an improvement, the receiver remains in the

15 wide-mode and continues to execute the loop 260-290 until a maximum time limit is exceeded, at 290. The receiver is preferably allowed to remain in the wide-mode for a limited amount of time only, to assure that the normal operation of the receiver, such as the aforementioned dynamic sensitivity adjustment, and so on, is maintained.

If, at 270, the measures obtained while in the wide-mode do not indicate an

20 improvement compared to those obtained in the normal-mode, the filter is returned to the normal-mode, at 210. Optionally, at 280, if the measures indicate that a change of environment has occurred, suggesting that the source of interference may have been removed, the filter is returned to the normal-mode, at 210, to re-assess the normal-mode conditions.

25

The following is a first preferred method of determining whether intermodulation distortion is present. This first preferred method has the advantage that the measures used to determine whether intermodulation distortion is present are typically available as digital signals within the baseband processor (160 of FIG. 1) of a typical zero-IF receiver (100).

30 Conventional portable receivers provide a measure of received signal strength, commonly termed the RSSI, that is commonly used to dynamically adjust the receiver

gain. Conventional portable digital receivers also provide a measure of the effective bit
energy relative to the noise floor, commonly termed the Eb/Nt ratio. For a given RSSI, a
minimum Eb/Nt ratio can be expected; and, up to a limit, the Eb/Nt can be expected to
increase with increasing RSSI. In the presence of intermodulation distortion, however, the

5   RSSI increases, but the corresponding increase in Eb/Nt ratio does not occur, because the
intermodulation distortion increases the noise floor, Nt, thereby reducing the Eb/Nt ratio.
Therefore, these two measures can be used to detect the presence of intermodulation
distortion, as detailed below.

      Using the example flow diagram of FIG. 2 as a reference, the block 230 is

10   configured to obtain the RSSI and Eb/Nt measures, averaged over about a millisecond. The
test block 240 compares the RSSI to a predefined minimum signal strength, and the Eb/Nt
ratio to a predefined energy threshold. If the RSSI is above the minimum signal strength,
and the Eb/Nt ratio is below the energy threshold, the receiver is placed in the wide-mode,
at 250, to filter-out second-order intermodulation distortion that occurs at zero-frequency

15   (DC).

      When the wide-mode filter is enabled, the measured signal strength can be
expected to decrease, regardless of whether intermodulation distortion is present, because
less of the received signal is being passed by the wide-mode notch filter. This decrease can
be predetermined, assuming the absence of intermodulation distortion, using techniques

20   common in the art of filter design. If, at 270, the measured decrease in received signal
strength is larger than the predetermined decrease, it can be assumed that intermodulation
distortion, or other anomalous interference within the notch-width of the filter, had been
present, and is now removed by the wide-mode filter. Also, at 270, if enabling the wide-
mode filter has decreased interference, the Eb/Nt ratio should increase relative to the

25   measured Eb/Nt ratio in the normal-mode. In a preferred embodiment, if either the
measured decrease in signal strength exceeds the predetermined decrease, or if the
measured Eb/Nt ratio increases, the wide-mode filter is considered to be doing "better"
than the normal-mode filter, and the receiver remains in the loop 260-290.

      At 280, if either the received signal strength or the Eb/Nt ratio increases

30   substantially compared to when the wide-mode was first enabled, it may be assumed that

the environment has changed, and the receiver is placed in normal mode, at 210, to invoke the aforementioned normal operations, such as dynamic sensitivity adjustment and others.

FIG. 3 illustrates a second preferred method of determining whether intermodulation distortion is present. This second preferred method has the advantage that it is independent of the baseband processor (160 of FIG. 1) and thus could be implemented regardless of techniques used in the baseband processor and could be embodied in any zero-IF receiver. A disadvantage of this method, however, is that it requires additional circuitry to provide the measures used to detect the presence of intermodulation distortion.

A detector 310 receives the output of the RF amplifier 110 and provides an estimate of the RF energy and the AM content of the received RF signal, for example via a squaring function. Another detector 320 samples the output of the amplifier 150 to provide an estimate of the RSSI. The outputs of the detectors 310 and 320 are provided to the intermodulation distortion detector 370. When intermodulation distortion occurs, the RF energy and AM content increase disproportionately to the increase in the RSSI. If the RF energy and AM content are high, but the RSSI is low, intermodulation is likely to be present, and the detector 370 places the receiver in the wide-mode to filter-out the intermodulation distortion.

FIG. 4 illustrates a third preferred method of determining whether intermodulation distortion is present. This third preferred method has the advantage that it can be embodied in either analog or digital form. As in the second preferred method, however, this method also requires circuitry that is not generally found in a conventional zero-IF receiver.

In this third method, two filters 410, 420 provide samples of the energy content in the baseband. One sample is taken at a low frequency in the baseband, within the band where intermodulation distortion is expected to occur (e.g. within +/- 60 kHz of DC), and the other is taken at a higher frequency within the baseband channel, but beyond the band where intermodulation distortion is expected to occur. The intermodulation detector 470 compares these two samples to directly determine the presence of intermodulation distortion, via an increase in the first sample without a corresponding increase in the second sample, and it will also directly indicate the cessation of the intermodulation distortion, via a subsequent drop in the first sample, while in the wide-mode, without a drop in the second.

The foregoing merely illustrates the principles of the invention in a variety of embodiments. It will thus be appreciated that those skilled in the art will be able to devise other arrangements which, although not explicitly described or shown herein, embody the principles of the invention and are thus within its spirit and scope. For example, one of ordinary skill in the art will recognize that the particular structures in the figures are presented for ease of understanding, and that the functions of the various blocks may be performed by other blocks. For example, some or all of the functions may be performed as digital functions in the baseband processor, as illustrated in FIG. 5. In this example, the baseband processor 560 includes the functions of the previously defined configurable notch-filter 130, the two sampling filters 410, 420, and intermodulation distortion detector 470. In like manner, the principles of this invention are not limited to a particular receiver configuration. For example, although this invention is presented in the context of a quadrature receiver, one of ordinary skill in the art will recognize that the principles presented herein are relatively independent of the modulation techniques used to communicate information via RF signals, and thus can be embodied in any zero-IF receiver system. These and other system configurations and embodiments will be evident to one of ordinary skill in the art in view of this disclosure, and are included within the scope of the following claims.

CLAIMS:

1. A method of reducing the effects of intermodulation distortion in a zero-IF receiver
(100), comprising:
    receiving an RF signal,
    modulating the RF signal to provide one or more baseband signals,
    detecting (240) an occurrence of intermodulation distortion within the one or more
baseband signals, and
    selectively enabling (250) a wide-notch filter (130) to attenuate signal components
of the one or more baseband signals within a predetermined notch-width of the wide-notch
filter (130), based on the occurrence of the intermodulation distortion.

2. The method of claim 1, wherein
    the predetermined notch-width is approximately +/- 60 kHz, and approximately
centered at zero-Hertz.

3. The method of claim 1, further including
    detecting (280) a cessation of the intermodulation distortion, and
    selectively disabling (280) the wide-notch filter (130), based on the cessation of the
intermodulation distortion.

4. The method of claim 1, wherein
    detecting (240) the occurrence of intermodulation distortion includes:
        determining (230) a plurality of signal strength measures, and
        determining the occurrence of intermodulation distortion based on a
relationship among the plurality of signal strength measures.

5. The method of claim 4, wherein
    the plurality of signal strength measures include:
        an RSSI measure, and
        an Eb/Nt measure; and
    determining the occurrence of intermodulation distortion if the Eb/Nt measure is
below a first threshold value when the RSSI measure is above a second threshold value.

6. The method of claim 5, further including
    selectively disabling (280) the wide-notch filter (130) when the Eb/Nt measure
substantially increases.

7. The method of claim 4, wherein
    the plurality of signal strength measures include:
        an RSSI measure, and
        an RF energy measure; and
    determining the occurrence of intermodulation distortion if the RSSI measure is
below a first threshold value when the RF energy measure is above a second threshold
value.

8. The method of claim 4, wherein

    the plurality of signal strength measures include:

        a first measure of energy in a first frequency band of the one or more baseband signals, and

        a second measure of energy in a second frequency band of the one or more baseband signals, the second frequency band being higher than the first frequency band; and

    determining the occurrence of intermodulation distortion if the first measure of energy is substantially higher than an estimated first measure of energy corresponding to the second measure of energy absent intermodulation distortion.

9. The method of claim 1, further including

    disabling (290) the wide-notch filter (130), based on a duration since enabling the wide-notch filter (130).

10. A receiver (100) comprising:

    a mixer (120) that is configured to convert a received RF signal to an analog baseband signal,

    a detector (170, 370, 470) that is configured to assert a detection signal when intermodulation distortion is detected in the analog baseband signal,

    a filter (130), operably coupled to the mixer (120) and the detector (170, 370, 470), that is configured to selectively attenuate signal components in the analog baseband signal when the detection signal is asserted, and

    a baseband processor (160, 560) that is configured to receive the analog baseband signal and to provide therefrom a receiver output.

11. The receiver (100) of claim 10, wherein

    the filter (130) is configured to selectively attenuate signal components within approximately +/- 60 kHz of zero-Hertz when the detection signal is asserted.

12. The receiver (100) of claim 10, wherein

    the detector (170, 370, 470) is further configured to de-assert the detection signal based on a duration since asserting the detection signal.

13. The receiver (100) of claim 10, wherein

    the baseband processor (160, 560) is further configured to provide digital measures of signal strengths in the analog baseband signal, and

    the detector (170, 470) is operably coupled to the baseband processor (160, 560) and is configured to detect the intermodulation distortion in the analog baseband signal based on the digital measures of signal strengths from the baseband processor (160, 560).

14. The receiver (100) of claim 13, wherein
    the digital measures of signal strengths include:
        an RSSI measure, and
        an Eb/Nt measure; and
    the detector (170, 470) asserts the detection signal when the Eb/Nt measure is
below a first threshold value and the RSSI measure is above a second threshold value.

15. The receiver (100) of claim 14, wherein
    the detector (170, 470) de-asserts the detection signal when the Eb/Nt measure
substantially increases.

16. The receiver (100) of claim 10, wherein
    the detector (370) is configured to detect the intermodulation distortion in the
analog baseband signal based on:
        a first measure of signal strength in the analog baseband signal, and
        a second measure of signal strength in the received RF signal; and
    the detector (370) asserts the detection signal when the first measure is below a first
threshold value and the second measure is above a second threshold value.

17. The receiver (100) of claim 10, wherein
    the detector (470) is configured to detect the intermodulation distortion in the
analog baseband signal based on:
        a first measure of energy in a first frequency band of the analog baseband
signal, and
        a second measure of energy in a second frequency band of the analog
baseband signal, the second frequency band being higher than the first frequency band; and
    the detector (470) asserts the detection signal when the first measure of energy is
substantially higher than an estimated first measure of energy corresponding to the second
measure of energy absent intermodulation distortion.

18. The receiver (100) of claim 17, wherein
    the baseband processor (160, 560) is further configured to provide the first and
second measures of energy to the detector (470).

19. The receiver (100) of claim 10, wherein
    the received RF signal is a quadrature-modulated signal, and
    the mixer (120) is configured to provide a pair of quadrature signals that comprise
the analog baseband signal.

20. The receiver (100) of claim 10, wherein
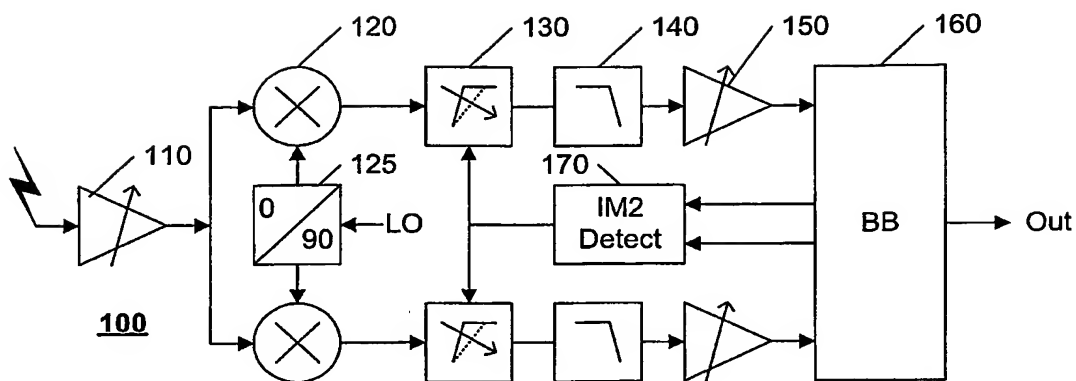   the filter (130) is a digital filter that is included within the baseband processor (160,
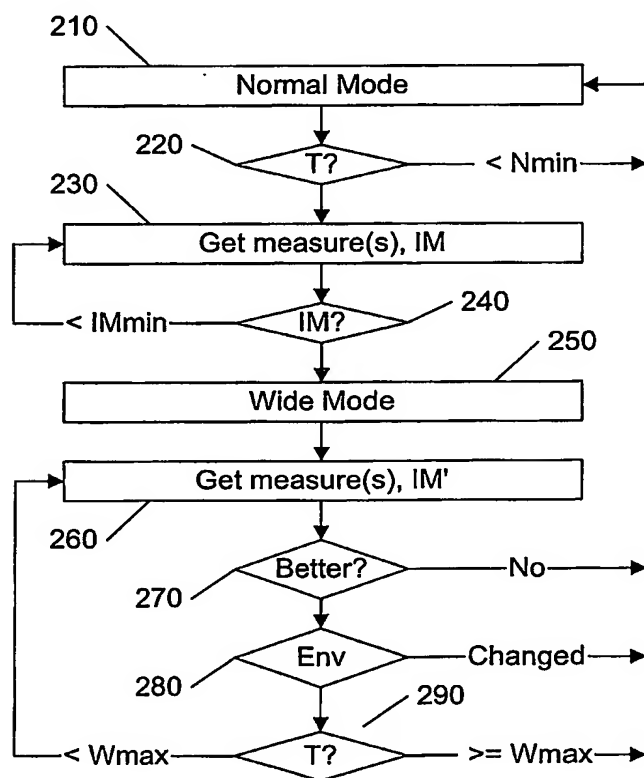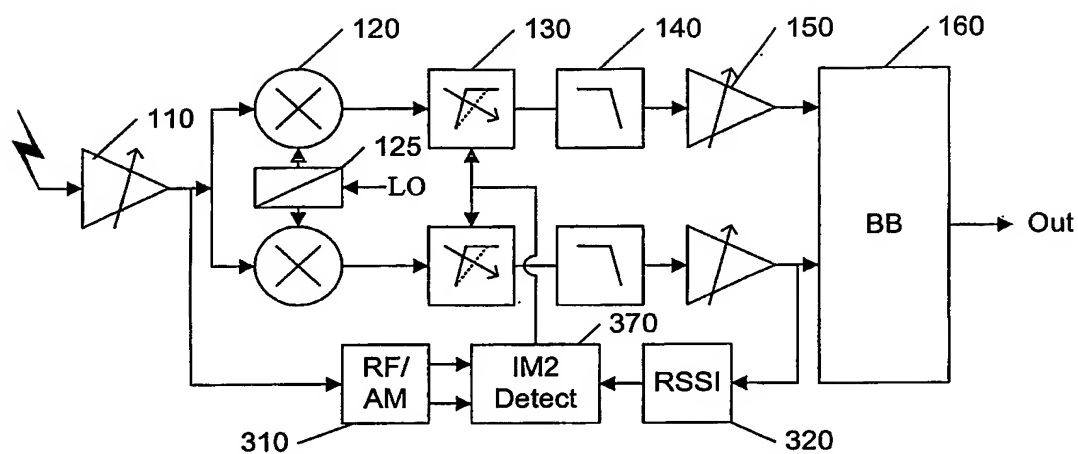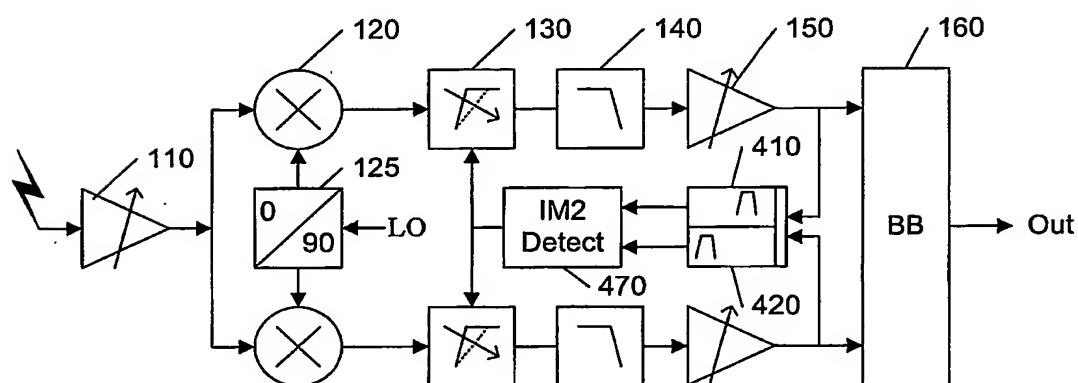560).

FIG. 1

FIG. 2

2/2

FIG. 3

FIG. 4
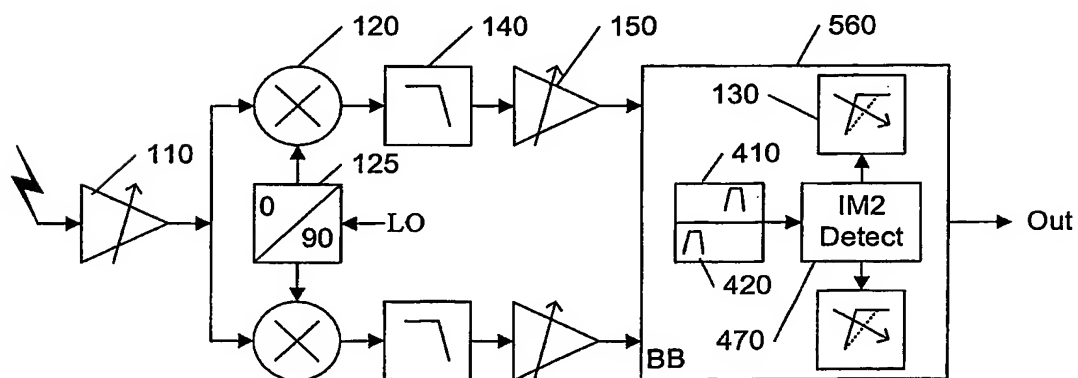
FIG. 5

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7   H04B1/10   H04B1/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7   H04B   H03D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category°	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 812 069 A (SHARP KK) 10 December 1997 (1997-12-10) the whole document	1-4, 8-12, 16-20
X	WO 01/69803 A (SMART TELECOM SOLUTIONS B V ; HOGERVORST ED (NL); NIE KEES DE (NL); ZW) 20 September 2001 (2001-09-20) page 3, line 22 - page 6, line 9; figure 1	1-4, 8-12, 16-20
X	US 5 519 890 A (PINCKLEY DANNY T) 21 May 1996 (1996-05-21) the whole document	1-4, 8-12, 16-20

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 October 2004	26/10/2004

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Beasley-Suffolk, D

Form PCT/ISA/210 (second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
EP 0812069	A	10-12-1997	JP	9326713 A	16-12-1997
			CN	1173101 A ,B	11-02-1998
			EP	0812069 A2	10-12-1997
			US	6035213 A	07-03-2000
WO 0169803	A	20-09-2001	WO	0169803 A1	20-09-2001
			AU	3464100 A	24-09-2001
US 5519890	A	21-05-1996	CA	2125468 A1	29-12-1994
			SE	9402246 A	29-12-1994